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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

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In the Matter of	)	
	)	
Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service	)	ET Docket No. 95-18

REPLY COMMENTS OF ICO SERVICES LIMITED

Francis D.R. Coleman
Director Regulatory Affairs - North America
ICO Global Communications
1101 Connecticut Avenue, N. W.
Suite 550
Washington, D.C. 20036

Cheryl A. Tritt
Susan H. Crandall
Morrison & Foerster LLP
2000 Pennsylvania Avenue, N.W.
Washington, D.C. 20006-1888
(202) 887-1500
Attorneys for ICO Services Limited

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REPLY COMMENTS OF ICO SERVICES LIMITED

ICO Services Limited ("ICO Services")[1] hereby replies to comments filed in response to the third notice of proposed rulemaking released on November 25, 1998 in the above referenced proceeding ("Third NPRM").[2]

SUMMARY AND INTRODUCTION

As one of the applicants seeking authorization to provide mobile satellite service ("MSS") in the United States at 2 GHz, ICO is keenly interested in the policies and rules being developed by the Commission for the provision of MSS in that spectrum. As such, ICO has been an active participant in this proceeding, and also has requested that the Commission expeditiously commence another proceeding for purposes of establishing

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[1] ICO Services Limited, a company established under the laws of England and Wales, is a wholly owned subsidiary of ICO Global Communications (Holdings) Limited, which is the ultimate parent of a wholly owned group of companies (referred to herein collectively as "ICO") that is developing a satellite system for the provision of global MSS.

[2] *Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service*, Memorandum Opinion and Order and Third Notice of Proposed Rulemaking and Order, ET Docket No. 95-18 (Nov. 25, 1998) ("MO&O" and "Third NPRM").

service rules for 2 GHz MSS.[3] The Commission in recent weeks has begun preparing a rulemaking proceeding with respect to such service rules.

ICO and the ICO USA Service Group ("IUSG")[4] recently have had discussions with staff of both the Office of Engineering and Technology ("OET") and the International Bureau ("Bureau") about the many issues addressed in both this proceeding and in the rulemaking request. These discussions have convinced ICO that the resolution of the 2 GHz transition issues that best balances the interests of 2 GHz MSS operators and incumbent terrestrial providers requires an integrated approach with a 2 GHz licensing scheme. Although they address separate issues, the 2 GHz transition and the 2 GHz licensing proceedings are, in fact, interrelated, and the Commission orders that will set forth rules in both proceedings must provide an integrated approach.

The key elements of proposals previously set forth by ICO and IUSG with respect to both the 2 GHz transition and licensing issues represent such an integrated approach. With respect to transitioning incumbent operators out of 2 GHz spectrum, the proposal previously set forth by ICO and IUSG allows for incremental transitioning of incumbents, rather than a simultaneous clearing of the band. ICO and IUSG also have proposed that the Commission adopt a sunset date of January 1, 2005, after which all

[3] *See* ICO Services Limited Petition for Expedited Rule Making to Establish Eligibility Requirements for the 2 GHz Mobile Satellite Service, RM-9328 (July 17, 1998).

[4] IUSG consists of British Telecommunications PLC ("BT"), Hughes Telecommunications and Space Company ("Hughes"), Telecomunicaciones de Mexico ("Telecom Mexico") and TRW Inc. ("TRW").

remaining non-MSS incumbent users of 2 GHz MSS spectrum would convert to secondary status.[5]

With respect to licensing of 2 GHz MSS, ICO has proposed that the Commission conditionally license all qualified applicants as an initial matter, but allow only those qualified MSS operators that meet specific milestones to have assured access to 2 GHz spectrum, to coordinate 2 GHz frequency with other qualified MSS operators, and to negotiate with incumbent primary terrestrial users with whom they cannot share spectrum. This approach ensures that incumbent 2 GHz terrestrial operators are not prematurely disturbed and is thereby consistent with an incremental transition approach.

As explained more fully below, the ICO/IUSG integrated approach ensures that (1) those qualified 2 GHz MSS operators that are ready to provide service near term will not be unnecessarily delayed in offering competitive services in the United States; (2) all qualified 2 GHz MSS applicants that have met certain milestones are assured of receiving access to some minimum amount of spectrum; and (3) an incumbent primary terrestrial operator need not relocate unless a qualified 2 GHz MSS operator cannot share the spectrum with that incumbent and is ready to occupy that spectrum. This integrated approach thus serves the public interest by facilitating the timely introduction of competition in the MSS marketplace in a fair and spectrum efficient manner and ensuring that 2 GHz terrestrial incumbents will be transitioned out of the spectrum only when necessary. In addition, such an integrated approach reflects a sensitivity to the

[5] ICO and IUSG have further proposed that the Commission condition all license renewals for 2 GHz incumbents issued after the March 14, 1997 release date of the FNPRM on those licenses converting to secondary status as of January 1, 2000. *See* Emergency Petition for Further Limited Reconsideration of BT, Hughes, ICO Services, Telecom Mexico and TRW (Dec. 23, 1998) ("Emergency Petition").

international implications of the Commission's approach to transitioning spectrum.[6] ICO strongly urges the staffs of the OET and the Bureau to work closely together to ensure Commission adoption of an integrated approach to the 2 GHz service rule proceeding and the 2 GHz transition proceeding.

I. THE COMMISSION SHOULD ADOPT THE ICO/IUSG INTEGRATED 2 GHZ MSS TRANSITION AND LICENSING APPROACH

As noted above, the introduction of competitive 2 GHz MSS in a timely, efficient and fair manner requires an integrated approach to both transition and licensing issues. ICO herein presents such an integrated approach, which brings together key elements of the 2 GHz transition and 2 GHz MSS licensing proposals previously set forth by ICO and IUSG to the Commission.

The ICO/IUSG integrated 2 GHz licensing/transition approach would permit expeditious entry into the U.S. marketplace by competitive 2 GHz MSS operators. Specifically, qualified 2 GHz MSS applicants would be conditionally licensed to operate across the relevant segments of the 2 GHz MSS bands, with subsequent intersystem coordination for those applicants meeting specified milestones to determine authorized frequency segments for each system. Conditionally licensed 2 GHz operators that meet the milestones will be assured of receiving at least a minimum amount of 2 GHz spectrum. As ICO previously has noted, the 2 GHz MSS processing round is characterized by applicants whose systems are at widely disparate stages of development. The ICO/IUSG integrated licensing/transition approach would ensure that those applicants, such as ICO, that are prepared to offer service near term, are authorized to do

[6] ICO would welcome an *en banc* hearing, as proposed recently by Commissioner Susan Ness, to consider the international implications of the Commission's satellite licensing
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so. The entry of new competition to the MSS marketplace should not be delayed because the systems of some applicants are not as well developed as the systems of other applicants.

The ICO/IUSG integrated 2 GHz licensing/transition approach also would promote efficient use of the spectrum. Only those qualified 2 GHz applicants that satisfy Commission imposed eligibility requirements would be conditionally licensed.[7]

The ICO/IUSG approach further would ensure spectrum access for later entering MSS operators. Later entering MSS operators would be assured a minimum amount of unassigned spectrum if they meet measurable milestones, including a "one year from launch" milestone. Earlier entering MSS operators would be obligated to coordinate with later entering MSS operators that satisfy the milestones.

The ICO/IUSG approach also would allow for maximum flexibility in spectrum assignment. Specifically, qualified 2 GHz MSS systems would be conditionally licensed across relevant portions of the band. Additionally, all 2 GHz MSS systems would be required to have sufficient frequency agility to allow band plan changes as practicable over time -- *i.e.*, as usage increases and spectrum is cleared.

ICO/IUSG approach also considers the needs of the incumbent primary terrestrial users of the 2 GHz MSS spectrum and avoids unnecessarily and prematurely disturbing these incumbents. Specifically, 2 GHz MSS operators would be encouraged initially to use the least congested spectrum so as to minimize the disturbance to the incumbents. Additionally, no incumbent would be transitioned out of 2 GHz MSS spectrum until that

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and transition policies. MO&O at 43 (Separate Statement of Comm'r Ness).

[7] ICO believes that new entrant 2 GHz MSS applicants should be conditionally licensed on an expedited basis.

incumbent's spectrum is actually needed by an MSS operator with whom the incumbent cannot share. As noted above, currently undeveloped MSS systems that are not approaching operational status could not require incumbents to move out of the 2 GHz bands.

To the extent that the Commission decides to impose relocation costs on 2 GHz MSS operators, the ICO/IUSG approach would minimize those costs.[8] An MSS operator would only be responsible for paying to relocate those terrestrial incumbents in spectrum the MSS operator actually uses and with whom the MSS operator cannot share.

The ICO/IUSG integrated approach also would impose a sunset date of January 1, 2005, after which all incumbent operations in the 2 GHz bands convert to secondary status and MSS systems may commence unconstrained operations in those bands.[9] This January 1, 2005 date is fair in that both Broadcast Auxiliary Service ("BAS") and Fixed Service ("FS") incumbents in the MSS uplink and downlink bands have been on notice that they likely would be required to relocate since at least 1995, when the Commission issued its original notice of proposed rulemaking in this proceeding.[10] Thus, by the sunset

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[8] As noted in ICO's earlier comments, it is ICO's position that it is inappropriate as a matter of policy and law for the Commission to impose upon global MSS operators the obligation to pay the costs of relocating domestic 2 GHz incumbents. *See* Comments of ICO Services Limited at 2 (Feb. 3, 1999). Without prejudice to its position, ICO supports IUSG's detailed proposals regarding transition issues, which are set forth in IUSG's comments.

[9] As noted above, the Commission also would condition all license renewals for incumbents issued after March 14, 1997 on those licenses converting to secondary status as of January 1, 2000 and the licensees paying their own relocation costs. *See supra* n.5.

[10] *See Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile-Satellite Service,* Notice of Proposed Rulemaking, 10 FCC Rcd 3230 (1995) ("NPRM").

date, the BAS and FS incumbents will have had ten years in which to transition out of the 2 GHz MSS bands.

As shown above, the ICO/IUSG integrated transition/licensing approach provides an effective, fair and efficient means of introducing new competition to the MSS marketplace. It allows for the timely entry of MSS systems that are ready to offer service near term, while simultaneously minimizing the disturbance to incumbent terrestrial users of the 2 GHz MSS spectrum. In addition, as shown below, it addresses a majority of the concerns raised by commenters regarding the introduction of MSS in the 2 GHz spectrum.

Further, ICO's licensing plan is superior to any licensing plan that calls for the 2 GHz MSS spectrum to be segmented equally among the nine 2 GHz MSS applicants and/or for the band to be cleared simultaneously. A licensing plan that calls for equal band segmentation is inefficient and wasteful in that it does not assign spectrum according to market demand. A licensing scheme that requires simultaneous band clearing will hinder the development of MSS systems by forcing MSS operators to incur premature relocation expenses and will unnecessarily disrupt incumbent licensees.

For these reasons, the ICO/IUSG integrated transition/licensing approach best serves the public interest. Accordingly, the Commission should adopt this approach.

II. THE COMMENTERS SUPPORT CRITICAL ELEMENTS OF THE ICO/IUSG INCREMENTAL TRANSITION PROPOSAL

The comments filed in response to the Third NPRM evidence support by numerous parties for critical elements of the ICO/IUSG proposal with respect to transitioning MSS operators into (and incumbents out of) the 2 GHz MSS spectrum. These comments reflect agreement with ICO's position that relocation of incumbents must be narrowly tailored so as to minimize the disturbance to those incumbents, as well as to lower the costs of relocation -- assuming the imposition of such costs -- on MSS operators.

Several parties agree, for example, with the key principle of the ICO/IUSG transition proposal that only primary BAS and FS incumbents that receive harmful interference are entitled to be relocated. Celsat America, Inc. states that "the Commission should require only those 2 GHz MSS licensees who cannot share spectrum with BAS or FS to pay relocation costs."[11] Globalstar, L.P. ("Globalstar") states "[i]t may be appropriate for satellite systems that can share with terrestrial incumbent stations not to pay relocation costs for incumbent stations licensed within an exclusive MSS frequency assignment."[12] In its discussion concerning the paired nature of the 2120-2150 MHz and 2165-2200 MHz bands, Inmarsat states that "[i]f the MSS licensees in question would have been able to share with the incumbent FS systems in the 2165-2200 MHz band, those MSS operators should not be required to contribute to or reimburse relocation costs necessitated by the introduction of other systems in the auctioned spectrum."[13]

Several commenters also agree with the ICO/IUSG position that the relocation model utilized by the Commission for Personal Communications Service ("PCS") is not necessarily applicable to 2 GHz MSS. Globalstar states, for example, that "[the PCS]

[11] Comments of Celsat America, Inc. at 2 (Feb. 3, 1999).

[12] Comments of Globalstar, L.P. at 5 (Feb. 3, 1999) ("Globalstar Comments").

[13] Comments of Inmarsat in Response to Third Notice of Proposed Rulemaking at 6 (Feb. 3, 1999) ("Inmarsat Comments").

relocation procedures were designed for a completely different scenario: relocation of FMS stations by PCS licensees with rights to exclusive spectrum in exclusive geographic markets."[14] Globalstar notes, as has ICO, that MSS operators will operate nationally and likely will be able to share spectrum with certain incumbents.[15] Similarly, TMI Communications and Company, Limited Partnership ("TMI") states that the relocation model utilized for PCS "is probably not a good model for this proceeding."[16] Application of the PCS model to 2 GHz MSS, warns TMI, "will likely create a system of vast complexity and huge expense for MSS licensees, which might render 2 GHz MSS untenable."[17]

A number of commenters, including broadcast interests, also agree with ICO and IUSG that an incremental transition proposal for incumbent BAS operators will ensure the availability of 2 GHz MSS in 2000 while providing for a more equitable transition of those incumbents. In their joint comments, Cosmos Broadcasting Corporation, Cox Broadcasting, Inc., Media General, Inc., and the Radio-Television News Directors Association (collectively, the "Joint Commenters") state that "[t]he Commission's proposed simultaneous retuning or replacement of all BAS equipment nationwide on a

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[14] Globalstar Comments at 2.

[15] *See id.*

[16] Comments of TMI Communications and Company, Limited Partnership at 4 (Feb. 3, 1999) ("TMI Comments").

[17] *Id.*

date certain is not even remotely practicable."[18] The Joint Commenters further state that "a carefully staged transition is essential to preserving local news coverage capabilities."[19] Constellation Communications, Inc. ("Constellation") also agrees with the phased-in approach, stating that "a transition plan should be established under which BAS facilities would be converted to digital transmission schemes while MSS systems were being placed into service."[20]

The Joint Commenters assert that the transition of BAS operations could be implemented on a staged channel-by-channel basis.[21] This is consistent with the IGO/IUSG proposal that BAS Channel 1 initially be rechannelized, with further rechannelization of BAS Channel 2 as MSS operators' need for spectrum increases. Such an incremental transition would serve the public interest because, as the Joint Commenters correctly note, "[v]aluable 2 GHz spectrum would not lie fallow while MSS licensees rolled out operations, and broadcasters would gain valuable experience using their new reduced bandwidth equipment while being afforded time to order and install the new equipment."[22]

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[18] Joint Comments of Cosmos Broadcasting Corporation, Cox Broadcasting, Inc., Media General, Inc., and Radio-Television News Directors Association at 7 (Feb. 3, 1999) ("Joint Comments").

[19] *Id.*

[20] Comments of Constellation Communications, Inc. at 4 (Jan. 19, 1999) ("Constellation Comments").

[21] Joint Comments at 9.

[22] *Id.* Any transition approach adopted by the Commission should afford sufficient flexibility to allow MSS operators to tailor relocation procedures to the needs of a particular market.

There is also support among the commenters for another key provision of the ICO/IUSG transition plan -- a sunset period that is substantially shorter than the ten-year period proposed by the Commission in the Third NPRM.[23] As Globalstar correctly states, "there is no apparent basis for the Commission to wait ten years for BAS stations to be deemed secondary in the 1990-2025 MHz band."[24] Globalstar further states that "[s]imilarly, with respect to [FS] stations, the use of an arbitrary 10-year period does not appear to be optimal."[25] Constellation recommends January 31, 2005 as the sunset date for BAS relocation, noting, as ICO has, that that date is ten years from the Commission's initial proposal to reallocate BAS spectrum.[26] Iridium LLC ("Iridium") proposes that the Commission set a sunset date "no later than the third anniversary of the date on which the Commission issues licenses to MSS operators."[27]

As ICO has explained, its proposed January 1, 2005 sunset date ensures that MSS operators will have more certainty as to their ability to provide service at 2 GHz at an earlier date. It further ensures that new entrant 2 GHz MSS operators need not wait ten years before being able to compete on a level playing field from a cost standpoint with their Big LEO competitors operating at 1.6/2.4 GHz.[28]

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[23] As noted above, ICO and IUSG specifically have proposed a sunset date of January 1, 2005.

[24] Globalstar Comments at 4.

[25] *Id.*

[26] Constellation Comments at 5.

[27] Comments of Iridium LLC at 4 (Feb. 3, 1999).

[28] A January 1, 2005 sunset date is also consistent with the WRC-95 allocation for 2 GHz MSS.

Finally, commenters support ICO's position that the Commission should freeze all applications for new BAS and FS licenses and for modifications of licenses.[29] TMI, for example, asks the Commission to impose a moratorium on new BAS and FS licenses in the 1990-2025 MHz and 2165-2200 MHz bands.[30] As TMI correctly explains, "the more stations which are operating in these bands at such time as relocation does take place, the more difficult and expensive [relocation] will be."[31] TMI further points out that "[t]he Canadian government has placed a moratorium on the licensing of microwave stations in the 1990-2025 MHz band, ensuring that any coordination conflicts are not compounded."[32] Inmarsat also urges the Commission not to license new BAS systems in the 1990-2025 MHz band, correctly stating that "[a]llowing additional new BAS systems to be licensed will only exacerbate an already difficult and complex technical situation."[33]

These comments indicate that there is support among both satellite and broadcast interests for key elements of the ICO/IUSG incremental transition proposal. Because this proposal serves the public interest by ensuring timely entry by MSS operators with minimal disruption to terrestrial incumbents, it should be adopted.

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[29] *See* Emergency Petition. Iridium previously supported ICO's position with respect to such a freeze. *See* Consolidated Comments of Iridium LLC on Petitions for Reconsideration at 3 (Feb. 22, 1999) (stating that ICO's Emergency Petition should be granted).

[30] TMI Comments at 6.

[31] *Id.*

[32] *Id.*

[33] Inmarsat Comments at 3. Consistent with the ICO/IUSG transition proposal, Inmarsat also urges the Commission to authorize modifications and extensions of incumbent systems on a secondary basis. *Id.*

III. FS AND BAS PROPOSALS TO EXTEND NEGOTIATION AND SUNSET PERIODS, THAT WOULD DELAY MSS MARKET ENTRY AND CREATE WINDFALLS FOR INCUMBENTS, MUST BE REJECTED

Several BAS and FS interests[34] oppose the Commission's proposals to establish: (1) one-year voluntary and one-year mandatory periods for non-public safety 2 GHz incumbent licensees; (2) a five-year total negotiation period for public safety FS incumbents (three-year voluntary and two-year mandatory period); and/or (3) a sunset period, after which new licensees are no longer required to pay relocation expenses.[35] Incumbents opposing the Commission's proposals seek longer transitions by extending negotiation periods or sunset deadlines, or by delaying trigger dates for negotiation periods.

The Commission must reject such proposals because they undermine any attempt to balance fairly the interests between new MSS licensees and incumbents and fail to recognize that certain 2 GHz MSS operators will be operating by 2000. Therefore, any

[34] *See* Comments of the Association of America's Public Television Stations at 7 (Feb. 3, 1999) ("APTS Comments") (if sunset rules in effect, MSS operators have an incentive to delay entering certain rural markets until after sunset passes); Joint Comments of the Association for Maximum Service Television, Inc. and the National Association of Broadcasters at 20 (Feb. 3, 1999) ("MSTV/NAB Joint Comments") (sunset of compensation not necessary because all BAS incumbents must convert to new band plan on date certain); Comments of the Society of Broadcast Engineers at ¶11B (Feb. 3, 1999) ("SBE Comments") (same); Comments of APCO in Response to Third Notice of Proposed Rulemaking at 2 (Feb. 1, 1999) ("APCO Comments") (opposes any sunset for public safety microwave incumbents; MSS license date begins count to 10-year sunset); Comments of the Association of American Railroads at 9 (Feb. 3, 1999) ("AAR Comments") (opposes any sunset); Comments of the American Petroleum Institute at 10 (Feb. 3, 1999) ("API Comments") (proposes 15-year sunset or initiate 10-year period at onset of involuntary relocation period rather than voluntary negotiation period); Petition for Clarification of UTC at 5 (Jan. 19, 1999) (clarify 10-year sunset date begins only after voluntary period begins for particular licensee).

[35] Third NPRM at ¶¶ 44 (BAS), 49-50 (FS).

proposals that extend relocation obligations beyond January 1, 2005 are untenable and must be rejected.

Specifically, several FS interests and BAS interests seek to start voluntary negotiation periods later than the July 22, 1997 date proposed by the FCC, or to extend the time for voluntary negotiation, or to eliminate entirely the voluntary period by requiring a single, mandatory, two-year negotiation period that begins 60 days after the effective date of the Commission's order.[36] A few BAS and FS interests also prefer extending the sunset period, either by seeking a longer sunset period or deferring the start date. The National Association of Broadcasters ("NAB"), the Association for Maximum Service Television ("MSTV") and the Society of Broadcast Engineers ("SBE"), with their simultaneous BAS relocation proposal, effectively propose dispensing with a sunset date.[37]

The Commission must reject proposals that seek to extend the obligations of 2 GHz MSS licensees to reimburse incumbents for relocation costs. Extended negotiation periods would delay provision of 2 GHz MSS service in the United States and serve only to allow incumbents to extract even greater relocation reimbursement costs for an expeditious relocation. Uncertainty about sunset dates also prevents MSS operators from making reasonable operational cost estimates. Transition plans, as described in the preceding sections, must be kept as short and predictable as possible. The ICO/IUSG

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[36] *See* API Comments at 6 (extend two-year voluntary); MSTV/NAB Joint Comments at 15-17 (single, mandatory two-year negotiation period; BAS incumbents should not be required to move to new spectrum before viable equipment is available; thus, extensions to two-year negotiation period must be granted).

[37] The MSTV/NAB and SBE proposal is premised on simultaneous relocation of the MSS spectrum by BAS. As noted above, however, simultaneous relocation is not practicable. *See supra* at 9-10.

transition proposal -- which requires MSS operators to pay the book value of the equipment of incumbents that are relocated, plus a flat two percent of that value to cover all other transactional costs, would not require extensive negotiation periods because relocation costs would not need to be negotiated.

A transition plan no longer than that proposed in the preceding section is reasonable for several reasons. First, all incumbents have been on notice of impending relocation since at least 1995, and FS incumbents have been on notice since 1992.[38] BAS and FS interests thus have had sufficient opportunity to contemplate their eventual relocation. In order to balance properly the interests of 2 GHz MSS operations and terrestrial incumbents, a sunset date no later than 2005 is required.

Second, because initial PCS and microwave FS negotiations resulted in protracted negotiation and in occasional premium payments for early relinquishment of spectrum, the Commission concluded that its initial voluntary and involuntary negotiation periods for FS relocation of C, D, E and F spectrum blocks of PCS were too lengthy.[39] Finally, extending the transition process unfairly exposes 2 GHz MSS operators to open-ended relocation obligations, driving up costs and delaying provision of competitive 2 GHz MSS in the United States.[40]

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[38] *See* NPRM, 10 FCC Rcd 3230; *Redevelopment of Spectrum to Encourage Innovation in the Use of New Telecommunications Technologies*, First Report and Order and Third Notice of Proposed Rule Making, 7 FCC Rcd 6886, 6891 (1992).

[39] *See* Third NPRM at ¶ 50.

[40] AAR'S conclusion that sharing between MSS and incumbent FS licensees is infeasible is premature and a thinly-veiled attempt to require MSS operators to relocate FS incumbents without regard to whether sharing is possible and therefore, must be dismissed. AAR Comments at 6-8. WRC-95, with some refinements by WRC-97 provides a complete framework using a "soft" PFD that protects FS systems operating in the same spectrum as MSS networks in the 2 GHz bands by triggering mandatory
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IV. A MAJORITY OF COMMENTERS SUPPORT ALLOCATION OF 85 MHZ FOR BAS INCUMBENTS

ICO has long advocated that an 85 MHz allocation for BAS was adequate to satisfy current and future equivalent BAS needs at 2 GHz and applauds the acceptance by SBE, MSTV, and NAB of the feasibility of an 85 MHz allocation for BAS. SBE states that it "supports the reallocation proposed in the Third NPRM."[41] MSTV and NAB state that they "believe that, with a good deal of effort and substantial lead time, ENG operations in the proposed allocation [of 85 MHz] can be made feasible through equipment modification or replacement."[42]

An allocation of 85 MHz for BAS is not only more than adequate but also capable of accommodating seven channels of analog FM BAS signal transmission in a 12 MHz (or 12.14 MHz) channel bandwidth for the vast majority of operational scenarios.[43] ICO has pointed out in its previous comments that digital technology provides enhanced performance over analog FM transmission and can support channel bandwidths even

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frequency coordination. *See* ITU RR No. S9.11A and App. 55 (formerly Annex 2 to ITU RR Resolution 46). The United States, as a signatory to the WRC-97 Final Acts, endorsed this system of protection. ICO, like Constellation, expects that the Commission could easily incorporate these engineering standards in its forthcoming 2 GHz service rules.

[41] SBE Comments at 1.

[42] MSTV/NAB Joint Comments at 3.

[43] In a small number of cases, it may be necessary to convert to digital transmission.

narrower than 12 MHz.[44] Testing conducted by Nucomm Inc.,[45] COMSAT Labs,[46] and recently Walt Disney Imagineering Research & Development, Inc.[47] provide further evidence of the high performance of digital transmission in narrow ENG channel bandwidths. This being the case, it is unreasonable for the Commission to require 2 GHz MSS operators to pay for the higher end digital implementation that provides enhanced capabilities when analog FM transmission in the reduced 12 MHz bandwidth would be adequate. In fact, SBE acknowledges that "any replacements or modifications [of existing TV BAS equipment] that simply implement the new band plan and without adding new capabilities should be deemed as justified and acceptable."[48]

Analysis and laboratory tests conducted by Sarnoff Corporation ("Sarnoff") at ICO's request -- the results of which are attached as Appendix A hereto -- demonstrate that analog FM TV signals can be readily transmitted in 12 MHz ENG channel

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[44] Digital television transmission can mitigate the effects of interference, fading, and multipath reception problems typical in analog FM transmission. At the same time, digital compression and transmission afford more efficient use of available spectrum, while maintaining a high audio-video quality signal. *See* Petition for Partial Reconsideration of the MSS Coalition, Exhibit A, *2 GHz Broadcast Auxiliary Services (Electronic News Gathering), Increased Spectrum Efficiency Through Digital Video Compression and Transmission* (May 20, 1997).

[45] Letter from Dr. John B. Payne, President, Nucomm, Inc., to Magalie Roman Salas, Secretary, Federal Communications Commission (Feb. 11, 1998).

[46] Letter from Bruce Henoch, General Attorney, COMSAT Corp., to Magalie Roman Sales, Secretary, Federal Communications Commission (Mar. 18, 1998.)

[47] *See* Comments of Walt Disney Imagineering Research & Development, Inc. at 1. ("After the reduction of the BAS Spectrum, the remaining 85 MHz could be divided into the same existing number of seven channels by allocating 12.14 MHz for each channel. . . . It is also possible to subdivide each channel into a number of sub channels, so that in the event certain applications need less bandwidth, multiple applications can be supported in that channel.").

[48] SBE Comments at 6.

bandwidths. Link margin[49] calculations (assuming a 20 mile range) show that most BAS ENG transmissions currently operate with very large link margins of approximately 30 dB.[50] It should be noted that in many instances, the typical range for ENG shots is considerably less than 20 miles. Such large link margins are clearly more than the level needed to accommodate the reduced 12 MHz channel bandwidth at a wide range of operationally practical peak deviation settings. Sarnoff tested the impact of a complete range of peak deviations from 1.05 MHz to 6.1 MHz at three receiver bandwidths of 10 MHz, 15 MHz, and 25 MHz, and assessed that "over-deviation to a much greater degree than suggested by Beakley's Rule was achieved in the tested ENG equipment without perceptible impairments of the video signal."[51]

Other test results further show that adjacent channel interference is not significantly worse at 12 MHz spacing than at 17 MHz spacing[52] and that the 12 MHz

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[49] Link margin is defined as the difference between available carrier-to-noise ratio and required carrier-to-noise ratio to achieve the desired signal level (picture quality) over the transmission path.

[50] Sarnoff Corp., *Technical Analysis of Impacts: Reducing 2 GHz ENG Channel Bandwidth from 17 MHz to 12 MHz* at 12 (Mar. 1, 1999).

[51] *Id.*

[52] Subjective tests of the equipment operating in the presence of an upper adjacent channel interferer showed minor degradation in its ability to operate at 12 MHz channel bandwidth (relative to 17 MHz channel bandwidth) without perceptible video impairments. Somewhat more degradation was noted in the presence of a lower adjacent channel interferer. For both 17 MHz and 12 MHz channel bandwidths, however, the presence of an adjacent channel transmitter would require, for the equipment tested, common operational techniques such as antenna offset pointing, channel coordination or polarization to achieve reasonable performance. These techniques should continue to be adequate in the 12 MHz channel bandwidth. *Id.*

channel bandwidth could still accommodate transmission of two audio subcarriers.[53] Sarnoff concluded that "both analysis and laboratory test results indicate the feasibility of reducing the analog ENG channel bandwidth from 17 MHz to 12 MHz with minimal equipment impact, while maintaining the existing service quality."[54]

Modifications to existing BAS/ENG equipment for 12 MHz operation are relatively trivial -- they primarily entail adjusting the peak deviation for the video and audio subcarriers (at the ENG modulator/transmitter), retuning or reprogramming to the new 85 MHz, 12 MHz-channel plan, and changing to a narrower bandwidth IF filter at the receiver, if such a filter is not already built into the receiver. SBE correctly points out that " 'retuning' BAS radios to the new and narrower channels would have to include narrowing the intermediate frequency ("IF") portion of the radios as well, as it is the IF portion of a receiver that provides the receiver's sensitivity."[55]

CONCLUSION

For the reasons set forth above and in ICO's comments, the Commission should adopt an integrated licensing/transition approach for 2 GHz MSS that is based on the licensing and transition proposals previously presented to the Commission by ICO and IUSG. As noted above, the ICO/IUSG integrated licensing/transition approach represents the most efficient and equitable means of ensuring the timely introduction of 2 GHz MSS. In adopting a transition approach for 2 GHz MSS, however, the Commission

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[53] Use of a second audio subcarrier, as supported by the tested ENG equipment, did not produce any perceptible video signal degradation when the audio subcarriers were appropriately spaced and modulated, with audio signal levels set accordingly. *Id.*

[54] *Id.* at 13.

[55] SBE Comments at 4.

should not apply -- or, alternatively, not apply wholesale -- the relocation and cost sharing policies adopted with respect to PCS. Finally, the Commission should adopt its proposed 85 MHz allocation for BAS at 2025-2110 MHz.

Respectfully submitted,

ICO SERVICES LIMITED

By: ______________________

Cheryl A. Tritt
Susan H. Crandall
Morrison & Foerster LLP
2000 Pennsylvania Avenue, N.W.
Suite 5500
Washington, D.C. 20006-1888
(202) 887-1500

Francis D.R. Coleman
Director Regulatory Affairs,
North America
ICO Global Communications
1101 Connecticut Avenue, N.W.
Suite 250
Washington, D.C. 20036

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APPENDIX A

ANALYSIS AND TEST SUMMARY REPORT

Impacts of Reducing 2 GHz Analog
ENG Channel Bandwidth
from 17 MHz to 12 MHz

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Prepared For:
ICO Services Limited

Prepared By:
Sarnoff Corporation
CN 5300
Princeton, NJ 08543-5300

SARNOFF Corporation

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1. Introduction

The FCC has issued a Third Notice of Proposed Rule Making (FCC 98-309) providing proposed "Rules to Allocate Spectrum at 2 GHz for Use by the Mobile Satellite Service". A portion of this Third NPRM addresses reallocation of Broadcast Auxiliary Service (BAS) spectrum, proposing reduction of BAS allocation from the original 120 MHz bandwidth (1990 - 2110 MHz) to 85 MHz bandwidth (2025 - 2110 MHz), and affirming the allocation of 35 MHz bandwidth (1990 - 2025 MHz) to MSS (Earth-to-space).

The Commission had previously concluded "that retrofitting or replacement of current equipment would suffice to reduce BAS from seven channels of 17 or 18 megahertz to seven channels of 15 megahertz"[1]. In the Third NPRM, the Commission notes that "[s]tudies and information that have become available since the adoption of the *First R&O/Further Notice* indicate that it is possible to transmit FM analog BAS signals in channels as narrow as 12 megahertz and digital BAS signals in channels as narrow as 10 MHz"[2]. A reference[3] suggests that 85 MHz of bandwidth could provide the seven distinct channels needed for BAS by utilizing six channels of 12 MHz bandwidth and one channel of 13 MHz bandwidth. In proposing to reallocate this 85 MHz to BAS, the Commission invites "comment on the feasibility of the proposed BAS allocation and on any other alternate allocations or measures that would mitigate the impact to BAS of the reallocations of BAS spectrum to other services".

Sarnoff Corporation (Sarnoff), at the request of ICO Services Limited, has conducted independent analysis and testing to determine the operational impacts of reducing the bandwidth of the seven analog ENG channels around 2 GHz from the current 17 MHz to 12 MHz (per channel). Our conclusion from this effort is that acceptable analog ENG operation is achievable under most current operational scenarios with the 12 MHz channel bandwidth at service quality comparable to the 17 MHz channel bandwidth. This report provides a summary of the overall effort and results.

2. Background

The 120 MHz BAS band from 1990 - 2110 MHz is currently used primarily for television Electronic News Gathering (ENG) purposes. For ENG, the band is structured as six channels of 17 MHz and one channel of 18 MHz, transmitting analog FM-TV NTSC signals from mobile vans to television studios for rebroadcast. The FCC has issued a Third NPRM regarding sharing of this band between satellite and ENG users. A portion of this NPRM addresses reallocation of Broadcast Auxiliary Service (BAS) spectrum, proposing reduction of BAS allocation from the original 120 MHz bandwidth (1990 - 2110 MHz) to 85 MHz bandwidth (2025 - 2110 MHz), and affirming the allocation of 35 MHz bandwidth (1990 - 2025 MHz) to MSS (Earth-to-space). The reduced BAS spectrum allocation is expected to be structured as seven channels of approximately 12 MHz.

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[1] See "Memorandum Opinion and Order and Third Notice of Proposed Rule Making and Order", FCC 98-309 at para. 31

[2] See id. at para. 32

[3] See Dr. J. Payne to M. Salas, Federal Communications Commission, February 11, 1998 (including a report entitled Digital Video Microwave Systems for STL and ENG: Applications & Test Results)

The conclusion from our analysis effort is that it is technically feasible to transmit analog FM BAS signals in 12 MHz channel bandwidths, consistent with prior studies, and that this should be practical under a wide range of actual operational conditions. Laboratory tests were then conducted to validate these analytic results for the actual operational conditions anticipated.

The test results did in fact validate the analytic conclusions, demonstrating that (for the equipment tested) it is technically feasible to transmit analog FM BAS signals in12 MHz channel bandwidths, and that even more extensive over-deviation than predicted by the analysis is possible without visible impairment of the video signal. At the 12 MHz channel bandwidth, adjacent channel interferers do not produce visible impairment of the video signal when coupled directly into the receiver as long as the interfering power level is at or below the desired signal. In operational settings, channel coordination, directional offsets of adjacent channel signals, and use of polarization are all techniques that can continue to be successfully used to reduce issues of adjacent channel interference even further.

3. Link Margin Effects

During the analysis effort, Sarnoff first analyzed link margin effects for the reduced 12 MHz channel bandwidth. A first order effect of reducing channel bandwidth could be to reduce the FM deviation, which would correspondingly reduce the signal-to-noise ratio (S/N). The operational impact of reduced S/N varies depending on signal strength, or link margin. In cases where a strong signal exists and S/N is adequate, reduced S/N predicted by standard analytic techniques may have no actual operational impact on equipment within the normal operational range and parameters.

The following calculations show the expected carrier-to-noise ratio (C/N) and typical link margin for analog ENG links at 12 MHz (using a technique known as "over-deviation", and with a single audio subcarrier), based on nominal data from equipment vendors.

Assume:

12W transmitter (10.8dBW) into 20" transmit antenna @ 2 GHz, giving gain G = 19dB
1.5M receive antenna, 3.5dB noise figure receiver, G = 28dB, T_S = 700°K, G/T = 0 dB/°K
Free Space Path loss, L, at assumed 20 mile (33 Km) range = 128dB
Bandwidth, B, at 12 MHz = 70.8dB Hz
Boltzmann's constant, k = -228.6dBW/Hz/°K

$$C/N = EIRP + G/T - k - L - B$$

$$C/N = (10.8 + 19) + 0 + 228.6 - 128 - 70.8 = 59.6\text{dB}$$

To achieve a S/N threshold of 54.4dB (considered to be a good figure of merit for high quality broadcasts), the required C/N is 30dB, leaving a link margin of 29.6dB. As derived, this link budget shows very large anticipated link margins at the normal operational range limit of 15-20 miles. Even at twice the normal operational range, 40 miles, a significant link margin of 23.6dB is achieved. This is comparable to a current link margin of 28.7dB for a range of 20 miles (and a link margin of 22.7dB for a range of 40 miles) at the 17 MHz channel bandwidth assuming Carson's Rule deviation and one audio subcarrier.

The link margins estimated above do not include secondary impacts such as multi-path fading or pointing error losses, or operational modes such as indirect reflection of the signal off nearby buildings. However, the estimated margins indicate that even with channel bandwidth reduced to 12 MHz, link margin is expected to be no more of a limiting factor than is currently the case for 17 MHz channel bandwidths in most operational scenarios.

4. Potential Improvement Using Over-Deviation

Transmission of analog (NTSC) television for distribution is accomplished by using FM modulation. This modulation approach uses frequency deviation, resulting in increased RF transmission bandwidth compared to AM modulation, but also improved signal-to-noise performance and fewer signal impairments from non-linearities of the circuits involved. There are some useful mathematical relationships that describe the effects of frequency deviation, modulating frequency range, and carrier-to-noise ratio on the received signal-to-noise ratio.

One important relationship, "Carson's Rule", relates the required RF bandwidth (BW) with the maximum modulating frequency (f_m) and total peak deviation (ΔF) in MHz for an FM signal. Carson's Rule is:

$$BW = 2(\Delta F + f_m), \qquad \text{where } \Delta F^2 = \Delta f_v^2 + \Delta f_a^2$$

Δf_v = video carrier frequency deviation
Δf_a = audio carrier frequency deviation

The fundamental FM equation that defines the critical relationship relating the unified CCIR weighted peak signal-to-noise ratio in dB (S/N) to carrier-to-noise ratio in dB (C/N) and frequency deviation (Δf) is

$$S/N = C/N + 10 \log (\Delta f^2 BW) + 3dB$$

where 3 dB is an accepted additive constant derived from the psophometric weighting factor, pre-emphasis/de-emphasis, and the specifics of the calculations used to determine S/N for television signals.

Using Carson's Rule to establish the baseline reference case for a 17 MHz channel bandwidth, the video peak deviation Δf_v is 3.1 MHz (assuming one audio subcarrier at a frequency of 4.82 MHz, with a peak deviation of 2 MHz, typical values for audio). The video signal-to-noise ratio, S/N_v then becomes

$$S/N_v = C/N + 25 \text{ dB}$$

Increasing ΔF beyond Carson's Rule is known as over-deviation. Note that using over-deviation increases S/N proportionally by $20\log\Delta F$, but may result in distortions in the demodulated video signal. These distortions can potentially impact the RS250C distortion parameters as well as threshold effects that produce impulse noise on black/white transition edges, thereby increasing the required C/N to achieve "no impulse" distortion. However in practice, some over-deviation is frequently used so that several dB of S/N improvement is obtained with only minimal detrimental effects on the demodulated signal.

One approach to determining the benefit of employing over-deviation is called Beakley's Rule, which modifies Carson's Rule by removing the factor of 2 on the modulating frequency, f_m. The equation then becomes:

$$BW = 2\Delta F + f_m$$

Using Beakley's Rule for the 12 MHz case gives Δf_v = 2.9 MHz (assuming single audio subcarrier at 4.82 MHz with 2 MHz peak-to-peak deviation). Thus, by using over-deviation at 12 MHz, it is expected that

$$S/N_v = C/N + 24.4 \text{ dB}$$

or only a 0.6dB reduction from the baseline 17 MHz reference case. Experience has shown that over-deviation using Beakley's Rule provides very acceptable quality video signals. Laboratory testing was conducted to validate these analytic results, and quantitatively determine the video quality effects of using over-deviation similar to the case analyzed above.

5. Testing Approach

Sarnoff conducted laboratory tests to measure the signal strength, signal distortion, and adjacent channel interference performance of analog FM ENG equipment operating at the current 17 MHz channel bandwidth, compared to its performance at 12 MHz using various FM deviation settings and associated audio sub-carrier parameters.

Signal Distortion Tests

Figure 1 shows the signal distortion test configuration used to assess the effects of varying video deviation, receiver bandwidths, audio subcarriers, and noise. A total of thirty-eight cases were tested, using various combinations of the indicated test parameters:

- Video carrier deviations of 1.05, 2.9, 3.1, 4.0, 5.39, and 6.1 MHz
- 0, 1, and 2 audio subcarriers were tested. When audio subcarrier(s) were used, the peak deviation was set to 1 MHz (the maximum obtainable with the tested equipment)
- Three receiver bandwidths: narrow, medium, or wide (defined by the manufacturer as 10 MHz, 15 MHz, and 25 MHz respectively)

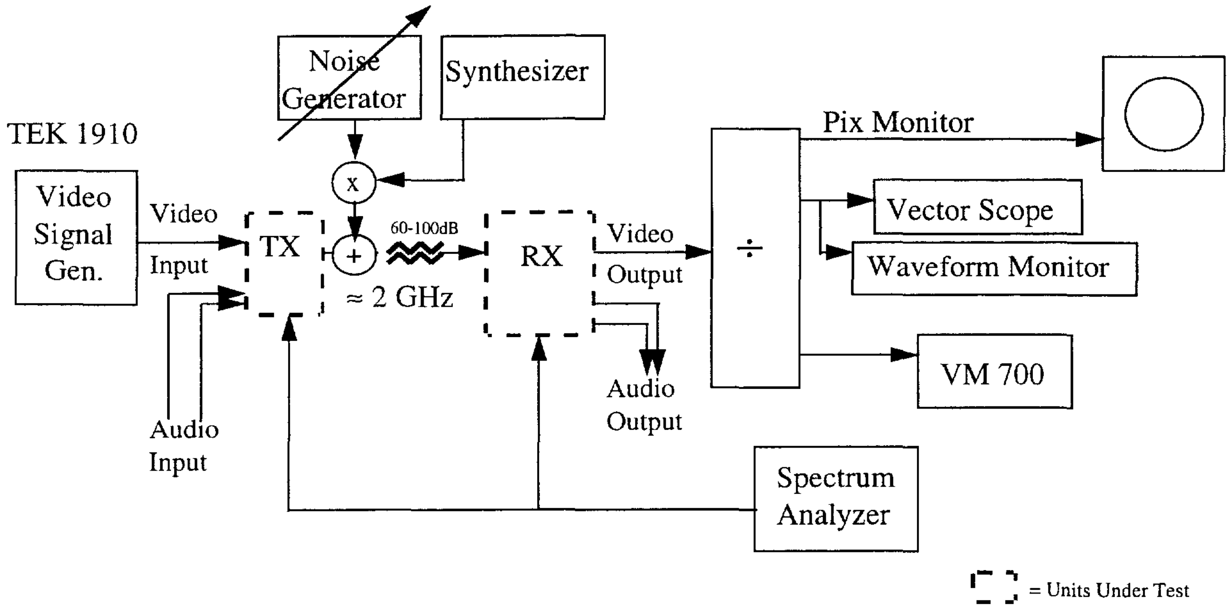

Figure 1. Signal Distortion Test Configuration

For these tests, both input and output signal levels were calibrated to 1 volt peak-to-peak using the waveform monitor. Additive noise in the transmission path was provided to ensure that the test setup was not receiver noise limited. Color bars and multiburst packets were used as input test signals applied to the video carrier. The signal distortion measurements were made using the VM700 video measurement set.

Adjacent Channel Interference Tests

Figure 2 shows the adjacent channel interference test configuration for both the 17 MHz and 12 MHz channel bandwidths. In this configuration, the noise generator has been removed, and the second transmitter added to provide the equivalent of an adjacent channel transmitter. These tests were conducted using one or two audio subcarrier(s).

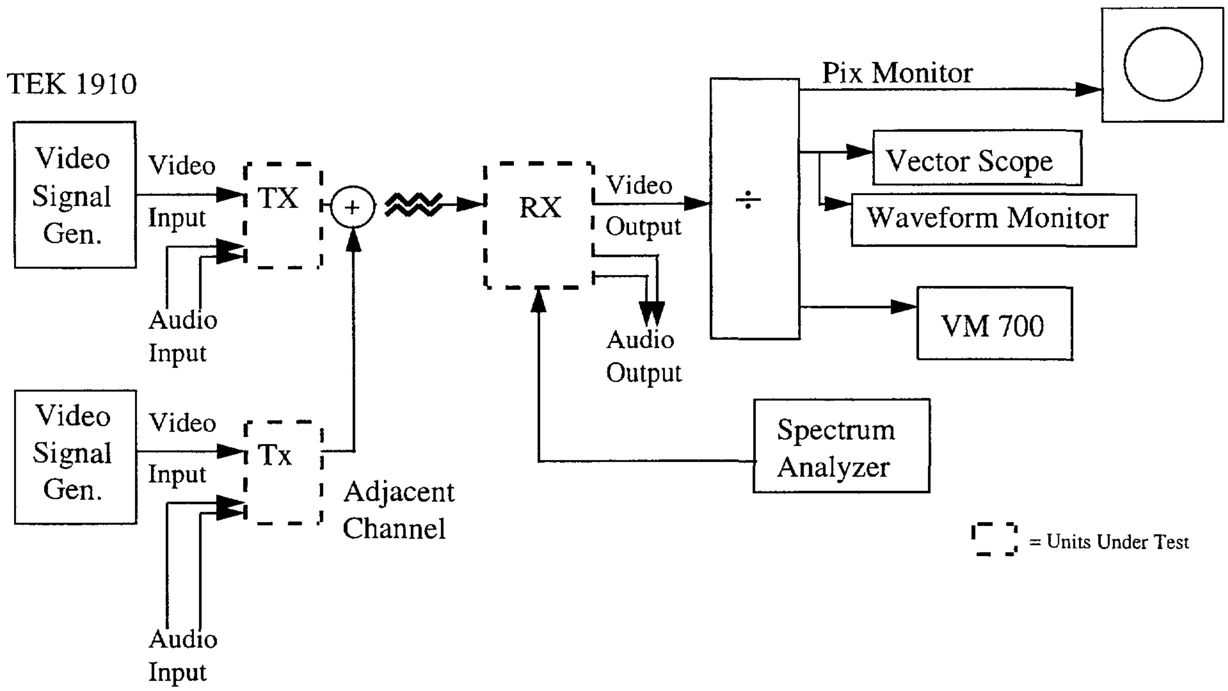

Figure 2. Interference Test Configuration

Eight interference cases were tested by varying the following parameters:

- Interferer signal at the upper and lower adjacent channels
- 17 MHz and 12 MHz channel bandwidth
- Receiver filter bandwidths – wide filter for both channel bandwidths, medium filter for the 17 MHz channel bandwidth, and narrow filter for the 12 MHz channel bandwidth

Three additional interference tests were run as references to validate the performance measured in the above cases, using the following parameters:

- Narrowest video deviation setting easily obtainable (Δf_v of 1.7 MHz) without audio subcarriers in the 12 MHz channel bandwidth
- Two cases at 4.0 MHz video deviation in the 17 MHz channel bandwidth, to provide baseline data representative of current operations. The first case used two unmodulated audio subcarriers in the interfering transmitter (worst case), and the second used two modulated subcarriers

The interference was measured using subjective tests in which several viewers were involved in reaching consensus on the level at which "just noticeable interference" (JNI) is seen in the desired video signal from the adjacent channel. The signal power is measured for both the desired and interfering signals at JNI, and the desired carrier-to-interference ratio (C/I) is calculated.

Equipment

The ENG equipment used for these tests was provided by NUCOMM, Inc. The two portable transmitter units were model number PT3, and the receiver units were model number 20CR4. The NUCOMM portable operates at about 1 Watt of output power and has no channel filtering. Audio subcarriers are on-off controllable, and include switchable operating frequency, adjustable audio deviations, and may also be modulated by external sources. The video carrier deviation is also adjustable.

6. Test Results

Signal Distortion Tests

Table 1 summarizes all the signal distortion test results for the 38 tested cases, in which the following parameters were adjusted:

- Video carrier deviation ranging from 1.05 MHz to 6.1 MHz
- 0, 1, and 2 audio subcarriers
- Three receiver filter bandwidths: narrow, medium, and wide (defined by the manufacturer as 10 MHz, 15 MHz, and 25 MHz respectively)

Channel Bandwidth Reduction Impacts

The first analysis of these results was used to validate the analytic predictions regarding S/N and video distortion resulting from the channel bandwidth reduction. The assumed baseline case (case #15) was a 17 MHz channel bandwidth with video deviation of 3.1 MHz (Carson's Rule). This was compared to 17 and 12 MHz channel bandwidths, with both signals over-deviated in accordance with Beakley's Rule (cases #21 and #11, respectively). These three cases are shown separately in Table 2.

As can be seen from the table, the 17 MHz baseline case achieved a S/N of 55.8dB, and over-deviation at the same channel bandwidth added 5.7dB of improvement for a total S/N of 61.5dB, while the over-deviated 12 MHz channel bandwidth signal achieved a S/N of 55.6dB, which is essentially equivalent to the baseline case. Video distortion parameters for the baseline case and the 12 MHz over-deviation case are virtually identical, supporting the conclusion that over-deviation can increase S/N without necessarily increasing video distortion.

Complete Distortion Range Test Results

Table 3 shows the impact of the complete range of deviation settings from 1.05 MHz to 6.1 MHz at the transmitter, and the associated measured results. At the 1.05 MHz deviation, video distortion parameters are still well below any perceptible impact on the video signal, but S/N is low. The mid-range deviation settings have regained S/N with no significant negative distortion impacts. Finally, the 6.1 MHz deviation setting has reached the hardware limit for S/N, and is beginning to suffer some distortion impacts to chroma-luminance gain % and differential gain % (although again well below perceptible limits). These results indicate that even more over-deviation than suggested by Beakley's rule is possible without perceptible impact to the video signal.

Table 1. Signal Distortion Test Results Summary

Case Number	Conditions		Receiver Input Signal = -42dBm				Added Noise* from HP3708A, dBm	Selected Output Video Parameters				
			Audio Subcarrier Frequency									
	Channel Bandwidth, MHz	Video Δfv Peak, MHz	4.83 MHz	5.8 MHz	Audio Subcarrier Peak Δfa	Receiver Filter Bandwidth		S/N Unified Luminance Weighted, dB	Chroma-Luminance Delay, ns	Chroma-Luminance Gain, %	Differential Gain, %	Differential Phase, Degree
1	12	1.05	On	Off	1 MHz	Medium	Off	46	27.7	117.6	1.89	0.57
2	12	1.05	On	Off	1 MHz	Narrow	Off	46.2	29.2	115.7	1.87	0.36
3	12	1.05	On	Off	1 MHz	Wide	Off	46	32.4	118.7	1.43	0.75
4	12	2.9	On	Off	1 MHz	Medium	Off	55.5	25.0	118.5	1.92	1.16
5	12	2.9	On	Off	1 MHz	Narrow	-49.5	53.1	-8.3	85.2	3.36	1.41
6	12	2.9	On	Off	1 MHz	Narrow	Off	56.8**	-7.8	84.9	3.29	1.55
7	12	2.9	On	Off	1 MHz	Narrow	-19.5	26.2°	7.4	88.9	4.76	6.79
8	12	2.9	Off	Off	Off	Narrow	-49.5	54.5	-8.1	85.0	3.55	1.66
9	12	2.9	Off	Off	Off	Narrow	Off	56.8	-7.3	85.1	3.33	1.55
10	12	2.9	Off	Off	Off	Narrow	-19.5	26.6°	7.8	85.1	5.22	3.53
11	12	2.9	On	Off	1 MHz	Narrow	Off	55.6	19.2	111.7	3.15	1.84
12	12	2.9	On	Off	1 MHz	Wide	-49.5	54.0	1.1	91.9	2.03	1.37
13	12	2.9	Off	Off	Off	Wide	-49.5	54.2	0.7	91.6	1.77	1.54
14	12	2.9	On	Off	1 MHz	Wide	Off	55.2	28.5	120.4	1.63	1.75
15	17	3.1	On	Off	1 MHz	Medium	Off	55.8	24.2	118.4	1.86	1.30
16	17	3.1	On	Off	1 MHz	Narrow	Off	55.7	18.2	111.1	3.34	2.06
17	17	3.1	On	Off	1 MHz	Wide	Off	55.6	27.8	120.5	1.49	1.74
18	17	4.0	On	Off	1 MHz	Medium	Off	54	-5.9	91.7	2.75	1.41
19	17	4.0	Off	Off	Off	Medium	Off	60.2	-5.2	91.7	2.84	1.69
20	17	4.0	On	On	1 MHz ea.	Medium	Off	54.7	-7.0	91.1	2.47	1.18
21	17	5.39	On	Off	1 MHz	Medium	Off	61.5	-6.3	91.9	3.86	1.92
22	17	5.39	Off	Off	Off	Narrow	-59.3	59.0**	-40.4	80.4	4.02	2.39
23	17	5.39	On	Off	1 MHz	Narrow	Off	57.9**	-40.8	80.5	4.01	2.30
24	17	5.39	On	Off	1 MHz	Narrow	-29.3°°	41.4	-41.3	80.5	5.28	2.26
25	17	5.39	Off	Off	Off	Narrow	-59.3	60.9	-43.0	80.4	4.10	2.27
26	17	5.39	Off	Off	Off	Narrow	Off	59.7	-41.3	80.4	3.94	2.25
27	17	5.39	Off	Off	Off	Narrow	-29.3	40.9	-41.5	80.4	4.27	2.70
28	17	5.39	On	Off	1 MHz	Narrow	-49.5	57.5	-40.6	80.0	3.83	2.27
29	17	5.39	On	Off	1 MHz	Narrow	Off	60.3	-41.8	80.4	4.02	2.31
30	17	5.39	On	Off	1 MHz	Narrow	Off	59.8	5.5	109.0	3.59	2.95
31	17	5.39	Off	Off	Off	Narrow	Off	61.2	-8.0	102.4	3.66	1.29
32	17	5.39	On	Off	1 MHz	Narrow	Off	60.5	-1.9	105.1	4.11	2.25
33	17	5.39	On	On	1 MHz ea.	Narrow	Off	55.8†	27.8	120.8	2.03	1.73
34	17	5.39	On	Off	1 MHz	Wide	-59.3	60.9	-16.8	93.2	2.18	3.65
35	17	5.39	Off	Off	Off	Wide	-59.3	58.6	-16.9	93.4	2.21	3.69
36	17	5.39	On	Off	1 MHz	Wide	Off	61.7	-5.9	91.7	2.15	3.12
37	17	6.1	On	Off	1 MHz	Narrow	Off	58.4**	-2.1	79.0	5.16	2.76
38	17	6.1	Off	Off	Off	Narrow	Off	63.6††	-28.8	80.3	3.96	3.22

* at -49.5dBm added noise, C/N is approx. 33dB (ultimately C/N approx. 30-35dB)
** hardware limit for max S/N (no noise added)
° signal below threshold, and reading not valid
°° C/N is approx. 13dB
† Intermodulation loss due to two audio subcarriers
†† greatest frequency deviation and S/N

Table 2. Channel Bandwidth Reduction Impacts

Case Number	Conditions		Receiver Input Signal = -42dBm				Added Noise* from HP3708A, dBm	Selected Output Video Parameters				
			Audio Subcarrier Frequency									
	Channel Bandwidth, MHz	Video Δfv Peak, MHz	4.83 MHz	5.8 MHz	Audio Subcarrier Peak Δfa	Receiver Bandwidth		S/N Unified Luminance Weighted, dB	Chroma-Luminance Delay, ns	Chroma-Luminance Gain, %	Differential Gain, %	Differential Phase, Degree
15	17	3.1	On	Off	1 MHz	Medium	Off	55.8	24.2	118.4	1.86	1.30
21	17	5.39	On	Off	1 MHz	Medium	Off	61.5	-6.3	91.9	3.86	1.92
11	12	2.9	On	Off	1 MHz	Narrow	Off	55.6	19.2	111.7	3.15	1.84

* at -49.5dBm added noise, C/N is approx. 33dB (ultimately C/N approx. 30-35dB)

Table 3. Complete Distortion Range Test Results Summary

Case Number	Conditions		Receiver Input Signal = -42dBm				Added Noise* from HP3708A, dBm	Selected Output Video Parameters				
			Audio Subcarrier Frequency									
	Channel Bandwidth, MHz	Video Δfv Peak, MHz	4.83 MHz	5.8 MHz	Audio Subcarrier Peak Δfa	Receiver Bandwidth		S/N Unified Luminance Weighted, dB	Chroma-Luminance Delay, ns	Chroma-Luminance Gain, %	Differential Gain, %	Differential Phase, Degree
2	12	1.05	On	Off	1 MHz	Narrow	Off	46.2	29.2	115.7	1.87	0.36
6	12	2.9	On	Off	1 MHz	Narrow	Off	56.8**	-7.8	84.9	3.29	1.55
16	17	3.1	On	Off	1 MHz	Narrow	Off	55.7	18.2	111.1	3.34	2.06
18	17	4.0	On	Off	1 MHz	Medium	Off	54	-5.9	91.7	2.75	1.41
23	17	5.39	On	Off	1 MHz	Narrow	Off	57.9**	-40.8	80.5	4.01	2.30
37	17	6.1	On	Off	1 MHz	Narrow	Off	58.4**	-2.1	79.0	5.16	2.76

* at -49.5dBm added noise, C/N is approx. 33dB (ultimately C/N approx. 30-35dB)

** hardware limit for max S/N (no noise added)

Table 4. Second Audio Subcarrier Test Results Summary

Case Number	Conditions		Receiver Input Signal = -42dBm				Added Noise* from HP3708A, dBm	Selected Output Video Parameters				
			Audio Subcarrier Frequency									
	Channel Bandwidth, MHz	Video Δfv Peak, MHz	4.83 MHz	5.8 MHz	Audio Subcarrier Peak Δfa	Receiver Bandwidth		S/N Unified Luminance Weighted, dB	Chroma-Luminance Delay, ns	Chroma-Luminance Gain, %	Differential Gain, %	Differential Phase, Degree
18	12/17	4.0	On	Off	1 MHz	Medium	Off	54	-5.9	91.7	2.75	1.41
20	12/17	4.0	On	On	1 MHz ea.	Medium	Off	54.7	-7.0	91.1	2.47	1.18
32	17	5.39	On	Off	1 MHz	Narrow	Off	60.5	-1.9	105.1	4.11	2.25
33	17	5.39	On	On	1 MHz ea.	Narrow	Off	55.8†	27.8	120.8	2.03	1.73

* at -49.5dBm added noise, C/N is approx. 33dB (ultimately C/N approx. 30-35dB)

† Intermodulation loss due to two audio subcarriers

Second Audio Subcarrier Test Results

A third set of test results analysis evaluated the impact of a second audio subcarrier, as supported by the equipment tested. Table 4 shows two cases (4.0 MHz and 5.39 MHz video peak deviation) - before and after the second audio subcarrier is added. The 4.0 MHz video deviation case is consistent with both Carson's Rule at 17 MHz channel bandwidth, and a highly over-deviated case at 12 MHz channel bandwidth. The 5.39 MHz video deviation case is consistent with Beakley's Rule at 17 MHz channel bandwidth.

The 5.39 MHz video deviation cases show some moderate increases in video distortion due to changes in chroma-luminance delay and gain % when the second audio subcarrier is added (although still well below perceptible limits), while the 4.0 MHz deviation case shows essentially no changes in video distortion parameters. These results validate the conclusion that a second audio subcarrier continues to provide acceptable performance in the range of cases of interest when working with 12 MHz channel bandwidths.

Receive Filter Bandwidth Impacts

Table 5 shows the impact of each of the three different IF receiver filters (narrow, medium, wide) on video distortion for the cases of 2.9 MHz, 3.1 MHz, and 5.9 MHz video peak deviations. The results again show minor variations in the video distortion parameters, but no significant variations as the receive filters change.

Adjacent Channel Interference Tests

The adjacent channel interference test data are provided in Table 6. As expected, these data indicate that the narrower filters provide better performance in rejecting adjacent channel interference. Combined with the results of Table 5, these results lead to a recommendation to use the narrowest receive filter settings available, consistent with the channel bandwidth employed.

The adjacent channel data also indicate, as expected due to the asymmetry of the video signal, that interference from the lower adjacent ENG channel is more of an issue than interference from the upper adjacent ENG channel. Most importantly, the test results indicate that for all cases, whether transmitting FM TV within 17 MHz or 12 MHz channels, equal strength adjacent channel transmitters pointing directly into the desired signal receiver will cause perceptible interference. Since this is true under current operational conditions at 17 MHz channel bandwidth, it is no surprise that operational solutions such as antenna offset pointing, channel coordination, and polarization are widely used. The change from 17 MHz to 12 MHz channel bandwidth does not significantly affect this operational issue, and it is expected that these same operational techniques will continue to provide acceptable performance at the 12 MHz channel bandwidth.

Table 5. Receive Filter Bandwidth Impact Test Results Summary

Case Number	Conditions		Receiver Input Signal = -42dBm				Added Noise* from HP3708A, dBm	Selected Output Video Parameters				
			Audio Subcarrier Frequency									
	Channel Bandwidth, MHz	Video Δfv Peak, MHz	4.83 MHz	5.8 MHz	Audio Subcarrier Peak Δfa	Receiver Filter Bandwidth		S/N Unified Luminance Weighted, dB	Chroma-Luminance Delay, ns	Chroma-Luminance Gain, %	Differential Gain, %	Differential Phase, Degree
4	12	2.9	On	Off	1 MHz	Medium	Off	55.5	25.0	118.5	1.92	1.16
11	12	2.9	On	Off	1 MHz	Narrow	Off	55.6	19.2	111.7	3.15	1.84
14	12	2.9	On	Off	1 MHz	Wide	Off	55.2	28.5	120.4	1.63	1.75
15	17	3.1	On	Off	1 MHz	Medium	Off	55.8	24.2	118.4	1.86	1.30
16	17	3.1	On	Off	1 MHz	Narrow	Off	55.7	18.2	111.1	3.34	2.06
17	17	3.1	On	Off	1 MHz	Wide	Off	55.6	27.8	120.5	1.49	1.74
21	17	5.39	On	Off	1 MHz	Medium	Off	61.5	-6.3	91.9	3.86	1.92
23	17	5.39	On	Off	1 MHz	Narrow	Off	57.9**	-40.8	80.5	4.01	2.30
36	17	5.39	On	Off	1 MHz	Wide	Off	61.7	-5.9	91.7	2.15	3.12

* at -49.5dBm added noise, C/N is approx. 33dB (ultimately C/N approx. 30-35dB)

** hardware limit for max S/N (no noise added)

Table 6. Adjacent Channel Interference Test Results Summary

Case Number	Conditions						Center Frequency Desired, MHz	Center Frequency Interferer, MHz	Signal Levels at "JNI"		
	Channel Bandwidth, MHz	Video Δfv Peak, MHz	Audio Subcarrier Frequency 4.83 MHz	Audio Subcarrier Frequency 5.8 MHz	Audio Subcarrier Peak Δfa	Receiver Filter Bandwidth			Desired Signal Level, dBm	Interfering Signal Level, dBm	Desired - Interfering (C/I), dB
A1	12	2.9	On	Off	1 MHz	Wide	2050.5	2063.25	-31.6	-40.9	9.3
A2	12	2.9	On	Off	1 MHz	Narrow	2050.5	2063.25	-32.2	-32.8	0.6
B1	12	2.9	On	Off	1 MHz	Wide	2050.5	2037.75	-31.4	-51.4	20.0
B2	12	2.9	On	Off	1 MHz	Narrow	2050.5	2037.75	-30.9	-47.0	16.1
C1	17	5.3	On	Off	1 MHz	Wide	2050.5	2067.5	-31.8	-38.8	7.0
C2	17	5.3	On	Off	1 MHz	Medium	2050.5	2067.5	-32.7	-32.7	0.0
D1	17	5.3	On	Off	1 MHz	Wide	2050.5	2033.5	-32.0	-59.7	27.7
D2	17	5.3	On	Off	1 MHz	Medium	2050.5	2033.5	-31.7	-39.5	7.8
E	12	1.7	Off	Off	1 MHz	Narrow	2050.5	2037.75	-39.3	-32.0	-7.3
F	17	4	On	On	1 MHz°	Medium	2050.5	2033.5	-32.0	-35.1	3.1
G	17	4	On	On	1 MHz°°	Medium	2050.5	2033.5	-32.2	-40.3	8.1

° Audio subcarriers unmodulated

°° Audio subcarriers modulated

7. Conclusions

The FCC has issued a Third Notice of Proposed Rule Making (FCC 98-309) providing proposed "Rules to Allocate Spectrum at 2 GHz for Use by the Mobile Satellite Service". A portion of this Third NPRM addresses reallocation of Broadcast Auxiliary Service (BAS) spectrum, proposing reduction of BAS allocation from the original 120 MHz bandwidth (1990 - 2110 MHz) to 85 MHz bandwidth (2025 - 2110 MHz). The analysis and testing efforts conducted by Sarnoff have provided a basis for evaluating the reduction in bandwidth on a per channel basis necessary to meet the 85 MHz allocation.

Our conclusions, based on independent analysis and validated by laboratory testing, are that acceptable ENG operation is achievable under most current operational scenarios at channel bandwidths of 12 MHz. Link budget analysis shows that current 17 MHz operations have a link margin of 28.7dB (for a range of 20 miles) assuming Carson's Rule is followed. At the reduced bandwidth of 12 MHz, the analysis shows that link margin is not expected to be the limiting factor over most current operational ranges.

Consistent with the analysis, test results show that (with the ENG equipment tested) over-deviation of the 12 MHz channel to the degree specified by Beakley's Rule resulted in comparable S/N with the 17 MHz channel bandwidth signal without over-deviation. This increased S/N in the 12 MHz channel bandwidth signal was achieved with only minor changes in the video distortion parameters. The result was a comparable quality video signal at 12 MHz channel bandwidth using over-deviation, compared to the 17 MHz channel bandwidth signal. Indeed, over-deviation to a much greater degree than suggested by Beakley's rule was achieved in the tested equipment without perceptible impairments of the video signal. Over-deviation is recommended as a normal operating mode at 12 MHz channel bandwidth.

Subjective tests of the equipment operating in the presence of an upper adjacent channel interferer showed minor degradation in its ability to operate at 12 MHz channel bandwidth (relative to 17 MHz channel bandwidth) without perceptible video impairments. Somewhat more degradation was noted in the presence of a lower adjacent channel interferer. For both the 17 MHz and 12 MHz channel bandwidths, however, the presence of an adjacent channel transmitter would require, for the equipment tested, common operational techniques such as antenna offset pointing, channel coordination or polarization to achieve reasonable performance. These techniques should continue to be adequate in the 12 MHz channel bandwidth.

Use of a second audio subcarrier, as supported by the tested equipment, did not produce any perceptible video signal degradation when the audio subcarriers were appropriately spaced and modulated, with audio signal levels set accordingly.

A notable characteristic of the ENG transmitter equipment tested was the lack of channel output filters. Without the need to change filters, changes in the transmitter channel bandwidth were achieved with simple laboratory or factory calibration procedures, and receive filter settings adjusted with front panel switches. To the extent that this equipment is representative of analog ENG equipment in the field, the reduction in channel bandwidth can be accomplished with minimal or no hardware changes.

Both analysis and laboratory test results indicate the feasibility of reducing the analog ENG channel bandwidth from 17 MHz to 12 MHz with minimal equipment impact, while maintaining the existing service quality.

CERTIFICATE OF SERVICE

I, James S. Bucholz, do hereby certify that copies of the foregoing **REPLY COMMENTS OF ICO SERVICES LIMITED** were delivered, via hand delivery, on this 5th day of March, 1999, to the following:

Chairman William E. Kennard
Federal Communications Commission
445 12th Street, S.W., Room 8-B201
Washington, D.C. 20554

Commissioner Susan Ness
Federal Communications Commission
445 12th Street, S.W., Room 8-B115
Washington, D.C. 20554

Commissioner Harold Furchtgott-Roth
Federal Communications Commission
445 12th Street, S.W., Room A-8302
Washington, D.C. 20554

Commissioner Michael Powell
Federal Communications Commission
445 12th Street, S.W., Room 8-A204
Washington, D.C. 20554

Commissioner Gloria Tristani
Federal Communications Commission
445 12th Street, S.W., Room 8-C302
Washington, D.C. 20554

Tom Tycz
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

Mindy Ginsburg
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

Sean White
Office of Engineering and Technology
Federal Communications Commission
2000 M Street, N.W., Room 427
Washington, D.C. 20554

Linda Haller
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 582
Washington, D.C. 20554

Cassandra Thomas
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

Dale Hatfield
Office of Engineering and Technology
Federal Communications Commission
2000 M Street NW, Room 480
Washington, D.C. 20554

Rebecca Dorch
Office of Engineering and Technology
Federal Communications Commission
2000 M Street NW, Room 230
Washington, D.C. 20554

Karl Kensinger
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

Tom Mooring
Office of Engineering and Technology
Federal Communications Commission
2000 M Street NW, Room 480
Washington, D.C. 20554

Christopher Murphy
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

Julius Knapp
Office of Engineering and Technology
Federal Communications Commission
2000 M Street NW, Room 425
Washington, D.C. 20554

Howard Griboff
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

Alexander Roytblat
International Bureau
Federal Communications Commission
2000 M Street, N.W., Suite 800
Washington, D.C. 20554

International Transcription Service
1231 20th Street, N.W.
Washington, D.C. 20036

James S. Bucholz

James S. Bucholz